Conservation Economics
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Module 3
Modern impacts necessitating conservation
Lecture 2
Plastics

Namaste! We carry forward our discussion on the modern impacts necessitating conservation and in this lecture we will have a look at plastics. Now plastics need no introduction - they are synthetic materials made from a wide range of organic polymers such as polyethylene, polyvinyl fluoride, nylon etc., that can be moulded into shape when soft and then set into a rigid or slightly elastic form.

So, what are the characteristics of plastics? They are synthetic materials. Synthetic material means that it is a manmade material. It is made from a wide range of organic polymers. So, it is not a homogeneous substance, but quite a large variety of chemicals can be formulated into plastics. Good examples are polyethylene, polyvinyl chloride, nylon and so on.

Now, the important characteristic of plastics is that they can be moulded into a shape when they are soft, which permits us to manufacture different kinds of substances using plastic materials. So, you can mould plastic into say a bottle, you can mould it into a pen, you can mould it into a chair and so on.

So, they have this important property that they can be moulded into a shape when they are soft and then set into a rigid or slightly elastic. So, it is no wonder that plastics surround us. In any room where you are sitting, if you look around you will find a number of particles that are made out of plastics and plastics surround us because they have some very good properties. They are cheap to manufacture, they are water resistant, they are light in weight, they are very strong and so on.

So, let us have a look at a short history of plastics. How did we come into this civilization of plastics? The earliest plastics in the terms of the synthetic material was made in 1600 B.C. when Mesoamericans processed natural rubber into a plastic. So, the natural rubber was converted into a plastic and this plastic was used as a ball. So, they used to play with this ball and the history of plastics is as old as 1600 B.C.

Then in the 19th century, polystyrene and polyvinyl chloride were invented and the 20th century saw the creation of a large number of plastics. In 1909 we had Bakelite that was used in commercial products. In 1926 polyvinyl chloride was commercialized and so it entered into the homes of a number of people. In 1933 Saran was invented. In 1937 Polyurethane foam was invented. In 1938 Teflon was invented. In 1939 we had Nylon and neoprene. In 1941 we had Polyester and PET and then a major change came in world war 2 when metals became scarcer and plastics started being widely manufactured to replace them.

Here again there was a trade-off - because people did not have access to metals and metals were very largely required for a number of things, so people started shifting towards plastics. This was a big trade-off during the 2nd world war. In 1951 high density polyethylene and polypropylene were invented. In 1954 Styrofoam was invented. In 1979 the plastic production in the United States exceeded the steel production

What we are seeing here is that the generation of plastics started and then it moved with a bang and then very soon it started growing exponentially. Plastic production is currently increasing at 5 percent per year and we see that a large quantity of plastics - more than 30 million tons is being produced every year.

We can relate this to the 10 principles of economics. A country's standard of living depends on its productivity. So, every country wants to manufacture more and more of the goods. And plastic again is one good that can be manufactured, that can be sold and that can be used in a number of ways.

So, a number of countries started to produce plastic. It was easy to produce. The raw materials that it required were easily accessible: petroleum and petroleum products, they are easily available, they are cheaply available and the technology to make plastics is also very simple. And so the plastics were produced in a very large quantity and soon we had plastic all over - all around us.

Now, the question is where does all this plastic go ? Plastics like every other material have a life. So, you take a bag of polythene, you buy some vegetables in it, you bring it to your home, you are going to use the vegetables, but then what do you do with the plastic?

Plastics because they are too cheaply manufactured and because of their good properties - they are manufactured in a large quantity. So, we have a large generation of plastic that is occurring in this world, but most of these plastics have a very short period of use . A number of plastics that are used in the manufacturing of bags - you bring your materials to your home in that bag and now you are not going to use this bag again.

So, what happens to all of these plastics? We use plastic disposable pens once we have used

these pens once they have stopped writing, what do you do with the pen? You throw them out into a dustbin. What happens after that?

In a number of biodegradable materials such as wood, once you have used a material once it has lost its properties once it is no longer useful if you put it out there in the environment there will be some organisms that will be acting on this wood and converting it back into the elements that find in the wood, mostly carbon hydrogen and oxygen - which is the basic premise on which our bio geochemical cycles work.

But in the case of plastics not many organisms can eat up a plastic and even if they eat a plastic very few organisms are able to digest this plastic. Now, the good properties of plastic that it is resistant to the impact of water it is resistant to the impact of chemicals and it is a strong substance also, means that it is resistant to the impact of enzymes in the bodies of organisms and that it is going to persist in the environment for a very long period of time.

So, what happens to these plastics? Well we have heard that plastics can be reused and recycled, but the fact remains that a very small percentage of plastics are ever reused or recycled. If we go back to this curve - this curve shows us the generation of plastics and this bottom curve shows us the recovery of plastics.

Recovery includes recycling. So, the amount of plastics that is being recycled is a very small fraction of the total amount of plastics that is being generated every year. So, a very small portion can be reused or recycled, but what happens to the rest of the plastic?

Well, some of the plastics are burnt, burning is an important method that is used in waste management because once you burn something you convert a fraction of it into gases that get released into the atmosphere and some portion that remains is of a smaller size and so can be handled easily.

So, for instance if you have large quantities of wood and you did not want to throw them out because you do not have access to landfills you can always burn the wood and if you burn the wood it will be broken down and it will be oxidized back into carbon dioxide and water, the substances that actually made the wood during the process of photosynthesis.

And the small amount of ash that remains will be rich in the nutrients, that is, like nitrogen and phosphorus and potassium. And this ash will be of a very small volume. It will be a very small mass and you can put this ash to some plant and this plant will use it back again because it is full of nutrients.

So, when you burn the wood the largest portion is burnt in the form of carbon dioxide and water and some portion that remains as ash can be used as a fertilizer for other plants. But, what

happens when you burn plastics? When you burn plastics you release not just carbon dioxide in water, but a number of other noxious chemicals such as dioxins.

Now, dioxins are chemicals that can very easily impact the development of a young child or the development of a fetus. They are extremely dangerous chemicals and when plastics are burned a large fraction of plastics also release dioxins.

Then a major portion of plastics is also put into the landfills. Landfill is a simple option if you do not know what to do with these plastics. What you do is that you just take it to an area and you dump it in that area. Landfill typically is a depression in the ground that is being filled with these plastics, but then remember that they are generating plastics at an ever increasing amount.

We have a large quantum of plastics that is being generated and we are now running out of space in the landfill. Now, remember again that plastics are very light materials, now if it is a light material it also means that it is going to occupy much greater volume as compared to a denser material. So, landfills quickly get filled up with plastics.

So, what happens? You are only reusing and recycling a very small fraction of plastics, when plastics are burnt they reduce dioxin. So, burning is not a good option, landfills are an option, but then we are running out of landfills.

What actually happens is that quite a lot of plastics are getting released into the environment. And even when you are putting plastics into the landfills it also gets released into the environment because some organisms might go to these plastics because it is all full of rubbish and you can have animals such as rats that are being that are living on this rubbish and so, when a predator comes and attacks a rat to eat it it it is also possible that it may also take away some of the plastics.

Also when it rains the plastics being lightweight materials they can float in water. And so if you have a landfill and if there is a heavy downpour and if the landfill is full to its brim it is possible that some of the plastics will start floating in water and they will move away. They will move together with the rain water in the form of surface flow and they will ultimately reach into the water bodies. So, they can reach into your ponds, they can reach into your lakes, they can reach into the rivers and ultimately they will also reach into the oceans.

Now the situation is that we have a material that is lightweight, strong, resistant to chemicals and this material is now spread everywhere. It is there on the land it is also there in all the water bodies, some portion of it may even sink. Now, if you ever wanted to collect all of this plastic bag, how are you going to do that? So, plastics become a menace because they are not being disposed of properly.

What happens to these plastics once they reach the oceans and the seas? 15 percent of these plastics float on the surface, 15 percent of the plastics wash to the shores and as much as 70 percent of the plastics sink to the ocean bottom .

What we are observing here is that some fraction keeps on floating because of its light weight; some fraction is washed off to the beaches. Now beaches have sand. People like to go to beaches, but now our beaches are also getting filled up with plastics because the ocean waves are bringing these plastics to the beaches. And then a major fraction of the plastics as much as 70 percent it sinks to the bottom. And we will look at how a lightweight material is able to sink to the bottom in the next few slides.

But in brief what happens is that if you have a plastic and if the container gets filled up with water or gets filled up with some other substance which is heavy in weight then the plastic might sink down. And also in a number of cases the plastics get eaten up by animals and the animals dive down, so the plastics also dive down together with them.

And the third way is that from the plastics when they get degraded they form smaller particles and these smaller particles remain suspended for a very long period of time, but then ultimately they also come down.

So, as much as 70 percent of the plastics sink to the bottom once they have reached the oceans. So, this is what it looks like. So, you have this water body and you can observe these plastics that are floating on top. Now, these plastics comprise a majority of single use plastics. So, these bottles were not meant to be reused and so people use them and then they throw them into a dustbin from where it goes to a rubbish heap and from there it has reached into a water body.

Or plastics can come to the shore and when they come to the shore some of the animals may start interacting with these plastics. And at the same time it also makes it very dirty . Or you can find plastics on the seabed. Here you can see this person is picking up certain plastics that are there on the seabed.

Plastics are classified on the basis of their size into 3 categories. We have macro debris, we have meso debris and we have micro debris. Macro means big in size so any plastic that is greater than 20 millimetre in size we will call it a macro debris. 20 millimetre is 2 centimetre. Anything that is more than this big we will call it macro debris.

Ghost nets amongst these are a major concern and we will have a look at ghost nets in a short while. Meso debris: meso means in between so it is a debris that has an in between size and we call 5 to 20 millimetre size plastics as meso debris. And they are dominated by nurdles; nurdles are resin granules that are intermediates in the plastic production.

What that means is that when plastics are produced chemically: plastics are polymers - so we start with monomers, we polymerize those monomers and then we get to a polymer. Now, this polymer is then formed in the form of small resin particles - they are like this big. And these resin particles are then sold off to other companies that are going to make use of these plastics.

Now, remember that when we started with plastics; plastics have the property that they can be moulded into a shape when they are soft. What these companies do is that they buy these nurdles then they heat them up so that they become soft and then these nurdles are processed to make the plastic products that the companies are manufacturing.

So, these nurdles which are like this big - we will call them meso debris. And in a number of cases they reach into the oceans because when they are being transported on a ship and if there is an accident if these nurdles are just released because one of the containers broke then these nurdles will directly reach into the oceans.

The third category is the micro debris micro means small. So, these are debris of small size less than 5 millimetre in size and they are often formed through fragmentation of macro or meso debris and they also consist of plastics rubber particles as are found in face wash and other cosmetic products.

What happens is that when we have the macro debris and we have the meso debris and when these plastics are acted upon by the UV rays of the sun or they are acted upon by the oxygen that is there in the air or because of mechanical action because if there is a plastic piece that is floating on water and together with the waves it can get thrashed with rocks or 2 plastic pieces can bump into each other and once that happens these plastics may break into smaller fragments.

The macro debris and the meso debris will break into smaller particles and ultimately they will form the micro debris. But, micro debris also comprises certain small particles that are manufactured that way less than 5 millimetres in size for use and cosmetics. So, these are the three size classifications of plastics: macro debris greater than 2 centimetre in size, micro debris less than 5 millimetre in size and meso debris everything in between.

When we look at the production of these smaller fragments the synthetic polymers have a number of things together with them. If we look at any plastic container such as this bottle of water. Now, this is plastic, but it also has a number of other constituents, so it has a stabilizer, it has certain fillers and it has a plasticizer.

These chemicals are added to the polymer which is the plastic to improve the properties. So, the stabilizer will stabilize this material. You would also want to add certain other substances that make it look much more transparent or add colors to it and so on.

When the large sized plastics reach into the atmosphere, when they reach into the environment they have all these stabilizers, fillers, extenders and other additives that are together with the plastic. When they reach into the environment they are acted upon by a number of things light acts on and especially the UV rays of the light are able to break the bonds.

The UV rays have high energy and they are able to break the bonds in these plastics. The plastics are polymers. If you break the bonds you will convert them into oligomers or into the monomers, and in this process the plastic piece will start to fragment into smaller sized particles.

A good example is if you take this bottle and if you keep it on your rooftop for a few months you will start seeing that it will slowly turn whitish in color and then it will start to become more and more brittle. And after a while it will start converting into smaller fragments.

The other thing that acts is oxygen. Oxygen is able to oxidize some of these substances: not just the polymer or the oligomers that are being formed, but also the stabilizers, fillers, extenders and other additives. When these chemicals get oxidized then they lose their properties and so the plastic becomes more and more brittle. And some biotech organisms such as microbes and worms can also act on these plastics.

And then we have a number of reactions. We have the absorption of light, especially this UV light and when the light is absorbed you can have a photolytic reaction.

Photolytic: photo means light and lysis is breakdown.This is a reaction in which there is a breakdown because of the light. In certain other conditions when light is absorbed it also leads to the heating up of the material, and when there is heating up of the plastic and if there is a differential heating then that will also lead to some amount of expansion and contraction which may lead to some more amount of fragmentation in these plastic particles. Because of the presence of oxygen and because of the presence of UV light you also have the formation of radicals.

Radicals also accelerate the process of degradation of these plastics. Or you can have enzymatic degradation when the plastics are acted upon by biological entities such as microbes and worms. And because of all these reactions: you have oxidation and you have scission. Scission is again a process of breaking down or cutting down. So, oxidation and scission reactions will lead to discoloration loss of mechanical integrity, strength and impact properties of the plastics and slowly and steadily the plastics will start breaking into smaller fragments.

Is this breaking good or bad? Well it depends. In certain cases you want to fragment these plastics into smaller particles so that you can dump them into a landfill in a much concentrated manner, but in a number of other cases it accelerates the process of these plastics being eaten. Because this large sized plastic bottle - there are very few organisms that will be able to eat this

plastic, but then if I have a small piece of plastic then it is possible that a fish or a bird may just confuse this material with food and might eat it.

So, these smaller fragments accelerate the process of plastics entering into the biosphere. This is how the decomposition occurs. When the plastics are acted upon by light water, oxygen and so on. We will see that in a number of these rubbish deep heaps you will find that you have a small piece of plastic film, now this is 1 millimetre so this is around say 2.5 or 3 millimetres, which means that it has now reached into the stage of being a micro debris.

Then you have these small foam particles. If you look at a big size Styrofoam we will call it a micro debris, but then if you look at the smaller pieces that come out and especially when they are acted upon and broken down further they will become into micro debris.

We have all these small fragments of plastics that are coming from a line: a line means that it is coming from a rope, then you also have these pellets or beads and especially those that are used in the cosmetic industry as exfoliators. You find all these different kinds of plastics in debris, you will find fibers, you will find film and so on. And these smaller fragments will be formed in the water body; it is also possible that they may start to aggregate together.

When they when these small particles aggregate together they form a middle sized particle that has a much greater density and in that case this fragment together in the form of the the aggregate it will start coming down in the ocean waters and slowly and steadily it will reach into the ocean flow and we call such things as marine snow.

Now, it is also possible that these smaller particles get eaten up by certain organisms and they are ejected out in the form of faeces. And all these processes the formation of the ecocorona or formation of faeces or or formation of marine snow they all make it possible for these smaller fragments to start going down to the ocean bottom.

When you have all these plastics what is the impact on the environment? And especially what is the impact on the different organisms that are there in the environment? What is the impact on the biodiversity that we have? Let us have a look at that. The first thing that can occur with plastics is that it can be eaten and in a number of cases the plastic bags are confused by a number of organisms as food.

If you look at these plastic bags they look very similar to jellyfishes and if there is an animal that naturally feeds on a jellyfish it may confuse these plastics as jellyfish and it will eat these plastics. Now, plastics because they are strong substances which are able to resist the impact of most of the chemicals so these plastics will not be digested in the body of these organisms that eat them.

What will happen to these plastics in the body? These plastics may enter into the alimentary canal these plastics may then start to block some portion of the alimentary canal. It is possible that these bags of plastics reach into the intestines and then they just remain there in the intestine and so there is a blockage that has been done.

Now, once that happens the animal will be unable to eat any food because there is a blockage in its alimentary canal and if that happens the animal will slowly and steadily start to die because it is not getting sufficient nutrition. This is an image of an albatross chick, now albatrosses are large sized birds and these birds also show a very great amount of parental care.

So, what happens in the case of an albatross is that the parents go out into the sea to catch fish and bring them to the baby. Now, if there is a piece of plastic that is floating on top of the water in the ocean it is possible for these birds to confuse this plastic as a fish. So, the parents will catch this piece of plastic, bring it to the chick and feed it to the chick.

And here we can observe that this was a chick whose body is all full of plastics. So, this is the amount of plastics that its parents had brought to it and fed it. And because of these plastics its alimentary canal got choked and this small bird died. So, albatrosses are facing a big danger because of these plastics that are floating on top of the water.

But we also observe ingestion in all sorts of organisms with their big or small. So, here is a blue colored microfiber. Here if you look at the size this much is 200 microns. This fiber would be like 500 micrometers that is half of a millimetre. And the thickness is a few microns and this sea pen polyp is a creature that lives in the oceans and here we can find that in this creature as well we are finding a plastic microfiber.

Now, remember that plastics are synthetic substances and before they were invented there were no plastics. All the other things that nature was making were biodegradable, but these plastics are not. So, we can observe plastics in large animals, we can observe plastics in small animals and we can even observe plastic in microscopic animals such as these zooplanktons.

Now, these green colored substances are micro plastics and we can observe that we have these micro plastics that have even impacted the microscopic organisms such as the zooplanktons. Ingestion is one big way in which plastics can impact the wildlife. Another way they impact biodiversity and wildlife is through entanglement, even smothering. So, what happens is that the plastics that are left out so they can be thrown out or probably they get out because of some accidents and these plastics can act as ghost nets.

Now, here we can observe that this is a fishing net that was there in the water body and the fishing net is meant to capture animals, it is very good at capturing animals and even when this fishing net is thrown into the ocean probably because its useful life was gone probably because it

had lost its strength. So, the fisherman had just thrown it into the water body, but then this ghost net was still capable of catching animals.

And here we can see that this turtle has been caught in this ghost net and when this turtle is caught, now this turtle is unable to move, this turtle is unable to feed and then slowly ends and steadily it will die out of starvation.

A number of other animals also require that they should be able to come to the surface, dive down, come to the surface for oxygen, dive down for food and so on. So, if these animals get entrapped when they are down at the bottom they will die out of asphyxiation, because they will not be able to come to the surface and breathe. If they get trapped on the surface they will not be able to dive to get their food. So, entanglement is also a major way in which plastics are decimating our biodiversity.

Another way is the example of the seal. Now, what happened was that this seal when it was a small pup, it got entangled with this piece of plastic. Now, plastics are very strong substances. This seal was unable to take it out, and then when this seal started to grow in size the plastic started to cut into its body. And here we can see that this plastic is cutting into the body of the seal.

And we can observe these things in a number of animals. I have seen some monkeys in the forest that have plastic that is tied across their waist and those monkeys are unable to feed because this plastic is pressing against their bodies. So, entanglement is also another way in which plastics decimate our biodiversity.

Another way is through the release of persistent bio accumulative toxic substances. Now, you will remember that plastics have these chemical stabilizers, fillers, extenders and other additives to improve their properties. Now, once you have released a plastic into the environment and this plastic is now floating on the surface of a water body these substances that were added into the plastic they can slowly get released out.

Now, these substances were added to the plastic to improve the properties and in a number of cases there was no consideration of how toxic these chemicals are when they are eaten up by organisms. And in a number of cases we find that these plasticizers are extremely toxic substances. So, if you release these plastics into a water body and these substances are slowly getting released into the water body, it is making the water body more and more toxic. It is leading to a degradation of the habitat that was earlier a prescribed habitat.

Another way in which plastics impact biodiversity is through the persistent bio accumulative and toxic substances. Now, bio accumulative means that these substances will accumulate in the bodies of organisms typically in the fat layer that is there in the bodies. These substances,

because they are organic chemicals, can easily get dissolved in fat and so they will accumulate in the fat bodies.

They are also persistent which means that they remain for a very long period of time. Which means that when these animals die these chemicals do not disintegrate, they remain persistent and so they will kill one animal because of their toxicity and when this animal dies these chemicals because they are still undegraded they again come back into the environment. And then they still maintain their toxicity levels and they still can kill some other organism.

So, these are persistent bio accumulative toxic substances. Good examples include bisphenol A which is an endocrine disruptor. Now bisphenol A is used as a plasticizer, when we say plasticizer if we look at this bottle it is able to maintain a certain amount of plasticity when you press it and it comes back into the original shape. It is soft and it is transparent.

So, chemicals such as bisphenol A are able to give these properties, but then bisphenol A is also an endocrine disruptor which means that it acts as a hormone, when it gets into the body and it disrupts the functioning of the normal hormones that are there in the bodies of the organism. So, this plasticizer when it is released into the environment can hamper the hormones that are there in the bodies of different organisms.

Another example of these chemicals is the brominated flame retardants that are used in the number of plastics. Now, brominated means that they are full of bromine and these are flame retardants that are typically used in things such as sofas or chairs. So, if there is a fire then plastics because they are made from petroleum and because they are hydrocarbons they can burn very easily.

And so to prevent accidents by law it is mandated that a number of these long term usage plastics should have brominated flame retardants. But, then these brominated flame retardants even though they are able to stop fires, but when these plastics are then thrown back into the environment and when these come out when they reach out they are also accumulative toxins. So, this is also another way in which plastics hamper biodiversity.

Another way is the accumulation and concentration of hydrophobic toxins. What does that mean? Plastics are hydrophobic substances. Hydro is water, phobic is fear of, so if you take a piece of plastic, if you add water to it then water does not wet the surface of the plastic, which tells us that it is a hydrophobic substance.

Now, if in water you add certain hydrophobic substances they tend to clump together. A good example is that if you take water and if you add a few drops of oil all of this oil will come together in the form of a layer. Now, when there is a piece of plastic that is out there in the water then all other hydrophobic substances will get attracted to this piece of plastic and they will

accumulate on the surface of this plastic, because this particle was fearful of water this plastic is fearful of water.

When both of these come together then at least this much part of the plastic as well as this particle is now not exposed to water. So, because of which these substances clump together.

Once that happens if you look at this water it has certain hydrophobic substances, probably toxic substances, but then they are there in a low concentration. But, if you put this piece of plastic and all these hydrophobic substances come and stick to the surface it means that now there is a much greater concentration of these hydrophobic toxic substances on the surface of this plastic. And we have seen before that plastics can get eaten up by different organisms both big and small, and once these organisms eat these plastics all of these hydrophobic toxins reach into the bodies of these organisms in a very high concentration.

This aids in the poisoning of our biodiversity. So, this is another way in which plastics impact our biodiversity. Then they also have the potential to alter habitats and behaviours. Habitat as we have seen is the natural home or abode of an organism and plastics have the potential to change the homes of animals. And once their homes are changed their behaviours also change.

For instance this is a crab that lives on the beaches and we have seen before that as much as 15 percent of the plastics get washed to the beaches. So, now the habitat of this hermit crab has plastics, earlier these hermit crabs did not ever observe a plastic, but now their habitats have these plastic pieces.

Now hermit crabs have this property that they make use of different shells of organisms as their protection layers. If you watch a hermit crab in most of the situations it would make use of the shell of certain molest animals and it will get inside these shells and these shells will provide protection to the hermit crab.

Now, what we are observing here is that this hermit crab is using a piece of plastic as its protection. Now, this is not a natural behaviour, this is an artificial behaviour which is there because this hermit crab is now finding quite a huge amount of plastics in its natural habitat. So, plastics have the ability to alter habitats and behaviours and this is also another way in which plastics impact wildlife.

This picture is showing us that there is a seahorse that is sticking to this piece of ear bud. Now, this is not a natural behaviour because in a pristine ocean, we do not have ear buds but now that there are ear buds in this portion the animals behaviour is changing. In a number of cases we find that animals are reaching into these rubbish dumps in the search of prey such as rats and now they are getting more and more exposed to these plastics.

We have the natural habitat of the hyena that has been disturbed, but at the same time the behaviour of these hyenas is also now getting disturbed. Because now they will look at plastic as something very natural and probably they will interact with these plastics. Earlier if it was a pristine environment and if a hyena found a red colored piece of plastic probably it would run away, but now it has been so much accustomed to these plastics then it might even try to eat up a piece of plastic. So, plastics have the ability to alter habitats and behaviours.

This is an image from Manas tiger reserve and this is the dung of rhinoceros, and what we are finding is that inside the dung we are finding pieces of plastic. This is a plastic bag, a blue colored plastic bag. So, even in a tiger reserve we are finding plastics have entered and animals are eating up these plastics.

Another way in which plastics impact biodiversity is by facilitating the dispersal and transport of invasive species. The dispersal as well as the transport and especially of invasive species. Now, what does that mean? A number of plastics are light in weight, they have a less density so they float on top of water.

Now, if an organism needs to move from one place to another it may just use this piece of plastic as a boat and together with this plastic it will move to some other location. Now, earlier the organisms did not have this option the only options that were there were say things like wood or a small piece of twig or a branch.

Now, those being biodegradable the organisms were unable to move to very far distances, but now that we have plastic in such huge quantities available to these animals these plastics are also acting as boats and rafts for a number of organisms for them and facilitating their movement.

Now, what happens is that a number of invasive species are also able to use these boats and rafts; plastic boats and rafts to reach other places and then they start to colonize the other places. And once that happens the local biodiversity may get decimated because the invasive species are able to out-compete the local species and then they establish themselves and they wipe off the local indigenous biodiversity.

So, this is also another way in which plastics are impacting our biodiversity. This paper showed us the incidence of rafting on marine debris by different taxonomic groups. And what are all the things? So, one is that you can find that different kinds of organisms are using plastics.

Sponges cnidarians worms sea spiders crustaceans molluscs bryozoans so many different kinds of organisms are making use of plastics. And they are using quite different varieties of plastic, ropes and netting fishing materials intact items packaging fragments and microplastics.

And if we have a look at the natural materials which are there in these colored forms and the

artificial plastics that are being used by these different organisms. So, say in the case of crustaceans this much amount of movement is happening because of the plastics and this much amount of movement is probably a natural movement.

So, we find that plastics have overwhelmed the system and they are increasingly being used as a means of transportation by different varieties of organisms and this is also increasing the possibility that a number of invasive species will be able to move from one place to another. And once that happens it will be a sad day for biodiversity.

Then, even micro plastics can influence the complete hierarchy. So, we can find that the microplastics are able to cause different impacts at different levels of the hierarchy. At the subcellular level we find that microplastics can influence enzyme activity; they can influence gene expression; they can influence oxidative damage. At the level of cells they can lead to apoptosis now apoptosis is programmed in death. So, microplastics may result in the death of different cells; it may hamper the membrane stability and may impact the phagocytic response.

Now, phagocytosis is the process by which a cell is able to eat. Now, if a cell starts to eat these microplastics then probably they will also impact the phagocytic response of different cells. At the level of organs they impact the histopathology, the metabolic demand of the organism and the energetic reserves that are there, because in the organs when plastics and special microplastics get accumulated then the energetic reserves are depleted.

At the level of individuals they may result in mortality; especially if an organism eats too much of these plastics and they impact a vital organ. Or they can impact the ingestion rates or the growth of the individual. At the level of population because the individuals are now not that fit and their organs are not working properly that will have an impact on the fecundity.

It may influence offspring viability because we have seen the case of this albatross in which the offspring viability was impacted because of the presence of plastics. And even and in the case of smaller organisms the micro plastics will also play a very similar role.

Now, the the saddest part here is that when this chick died because its body was all full and blocked by these plastics the body of the of this albatross chick because it is made out of biodegradable materials it will slowly degrade, but then these plastics because they are non biodegradable they remain persistent.

So, what will happen is that with the next range the these plastics will be able to come back they will again come back into the oceans and probably they will be picked up by some other albatross. So, this process goes on and on and so these plastics may result in the deaths of quite a large number of organisms. At the level of the ecosystem we have seen that plastics influence the behaviour of different organisms.

We have seen the image of this hermit crab which is now using this plastic or we have seen that a seahorse is using this plastic. Now, what happens is that if a particular species becomes too much acclimatized with these plastics it may change its behaviour to such an extent that certain other species may also get impacted.

So, for example, to take a simple example we can consider the pollination that is done by different birds and different insects. Now, suppose you have quite a large number of red colored or bright colored plastics that are strewn around on a field and suppose insects must take them for flowers and they land on these plastics and they spend all their time on these plastics in search of food.

So, they are not going to the flowers and in that case the pollination that these insects were doing in the flowers will get impacted. And so, because of the change in the behaviour of the bees and the insects the species of plants will also get impacted. So, at the ecosystem level as well we can observe different detrimental effects that are being brought about by these plastics.

So, how can we help? Well the good old technique is reduce reuse and recycle, reduce the amount of plastics that you use on a daily basis. As far as possible you reuse the components that are made out of plastics. So, if possible do not throw this bottle once you have used the water you probably fill this bottle again and you use it for some more time.

So, reduction in the use of plastics, reuse of plastics and recycling of plastics such as in this recycling facility are very important. But then if you want that people should go for reduction, reuse or recycling what needs to be done as we have seen in the principles of economics incentives need to be provided.

You need to induce people so that they shift away from plastics and they reduce reuse and recycle plastics as much as possible. And so economics plays a very important role here. Economics made it possible for plastics to come up in such a big way because they increased the living standards of different people, but then we can also make use of principles of economics to tackle this problem. Or we can induce people to go for lifestyle changes, use glasses in place of the straws or go for alternative materials such as bioplastics.

So, these days we also have biodegradable plastics that are made from natural products that have very similar properties. So, they are like this film of the bioplastic: it is completely transparent, it is flexible, you can mould it, you can bend it. And the strength of these bioplastics is similar to or greater than the strength of the common plastic such as the low density polyethylene. Or if we go for a bacterial cellulose composite of this plastic it is even greater than that of the high density polyethylene.

So, we have alternatives available with us, but then how do you induce people to shift into bioplastics? Again we have to make use of incentives. So, at all points of conservation we need to correlate the 10 principles of economics. Now, here the principles that are the most important are people and society face tradeoffs. Now, here the trade off is earlier. We shifted to plastics because the trade off was during World War 2, we did not have access to metal and so we shifted to plastics as a trade off.

But then once we shifted to plastics we improved their properties to such an extent that now plastics have become the mainstay and after a while they even overcame the amount of production of steel or of another material. So, there is always a trade off and this trade off has made it possible for people to shift to plastics.

But now again we are facing other trade offs. Now, the trade offers that we do not have sufficient landfills, our biodiversity is going down and these plastics are also leading to a large amount of pollution, they are leading to a large amount of filth and our beaches are dirty.

So, the use of this plastic started with a trade off because we did not have metals and the disuse of plastics is also being facilitated by a trade off. Because you have two options you can either use plastics and suffer all these consequences or you can shift away from plastics and save yourself from these consequences.

So, everywhere there is a trade off, and these trade offs lead to cost. Now, there is a short term cost and there is a long term cost. Now, in the short term manufacturing of plastics is cheaper so people shifted to plastics, but then the long term cost or the life cycle cost the cost of picking up all these filths and the cost of processing these filths is too large. The cost that we are suffering in terms of the loss of biodiversity is too large. So, this is an important economic principle that can save us from plastics; but we will have to emphasize the negative cost that we are facing because of the use of plastics.

Another important principle is that people respond to incentives. So, how do you incentivize people to reduce reuse and recycle? Well in a number of cases people have come up with an alternative that if there is a vending machine and if you put a used bottle into this machine you will get certain money out of it. So, this money is an incentive to promote people not to throw the plastic out into the litter, but to bring it to a machine where it can be easily recycled.

Another alternative incentive that has been formulated is provisioning of subsidies in the manufacturing of biodegradable plastics. Or provisioning of taxes in the case of manufacturing of petroleum based plastics. So, people respond to incentives and so if we want people to move away from these petroleum based plastics we will have to impose certain costs. And if you want people to shift towards biodegradable plastics or to reduce reuse or recycle we will have to facilitate that with certain incentives and here also comes the role of the governments.

Because these taxations and subsidies in most cases are given by the government they are implemented by the government. So, governments can improve market outcomes and in this case the market outcome in the case of plastics is not the most efficient one.

Because if the government did not intervene then there is a huge externality with the use of plastics because if I use if I use plastic I I carry all the benefit of the usage, but the cost of its littering the cost of biodiversity loss or the cost of making the surroundings dirty is born not just by me, but by everybody else.

So, it makes it possible for me to use the plastics more and more because I am not paying the cost, but then if the government comes up and says that ok we need to internalize these externalities through taxations and through subsidies . So, if somebody is using plastics we are going to tax it more, if somebody is using biodegradable plastic we are going to provide him or her a subsidy. If these things come up then probably the market will shift to a more optimum level.

So, the government can sometimes improve market outcomes and also a country's standard of living depends on its productivity. So, earlier we saw that the levels of plastics increased so much the production increased so much because most of the countries were emphasizing that we need to produce more and more.

Now, today as well we need to have more and more of different products, but then if we can emphasize that these products not only need to be cheap, but they also need to be environmentally friendly then probably we can shift away from the nuances of these plastics.

So, that is all for today. Thank you for your attention. Jai Hind!